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SHOULD HOMOGENEOUS-IMMERSION OBJECTIVES BE MADE ADJUSTABLE OR NON-ADJUSTABLE ?

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The question presented for consideration in this paper is by no means one of purely speculative or theoretical optical interest, but is one of great practical importance to every advanced worker with the microscope of the day.

We often hear the costly and delicate workmanship of our modern lenses decried as unnecessary because "most of the discoveries with the microscope have been made with lenses now considered inferior." Admitting, for the sake of the argument, that this statement is true, it by no means follows that the more perfect instruments of to-day are not needed. The work of the inferior lenses has been *done*—the work that is yet *to do* requires the very finest products of the optician's skill, that it may withstand the more enlightened criticism of to-day and of the future.

The introduction of the homogeneous-immersion plan (so-called) was doubtless a great step in advance, as it gave opportunity for the simultaneous increase of aperture and working distance in high-power lenses. Two, at least, of the most eminent makers of this class of lenses, claim for them another advantage, viz., that of dispensing with the adjustment for correctness or varying thickness of cover. Other makers, equally eminent, retain this adjustment in lenses of this class; and the question as to which is the better plan remains an open one for the present.

On the one hand it is urged that the non-adjusting lenses are best, because:

First, lenses of extreme aperture are proportionally sensitive to slight displacements of the centering of their component systems, and that in the non-adjusting form of mounting they are accurately centered by the maker and protected from the possibility of decentering arising from the imperfections of the screw of the adjustment collar.

Second, that adjustment by means of a correction collar, which changes the distances between the systems of an objective, is, at best, but an expedient; that there is *one best* position, and that the lenses can be fixed in this position by the maker in a non-adjustable mount.

Third, that good adjustable mounts are necessarily expensive and add unnecessarily to the cost, already considerable, of first class wide-angled lenses.

Fourth, it is urged by some microscopists that "it is too much trouble to correct adjustable lenses." This being a lazy man's objection, may be dismissed without further consideration.

To these objections to the use of adjustable mounts, the following seem to me to be conclusive replies:

First, if the brass-work is done with a degree of skill at all commensurate with that necessarily expended on the glass-work of a really first class homogeneous-immersion objective (so-called), there need be no fear of injurious decentering of the systems by the movements of the adjustment collar.

Second, while it is true that the adjustment by means of varying position of the systems is only an expedient, yet if it can be shown that it reaches the desired end more certainly, speedily and accurately than any other, the objections to it must fall to the ground.

Third, that while it is conceded that really first-class metal work is expensive, if it can be shown that it is *necessary*, the objections to it must also fall.

Now, in support of these last two propositions, it is necessary to call attention to the fact that the advantages of homogeneous-immersion (so-called), great as they undoubtedly are, have been, in some directions, over-rated, and that some microscopists have been misled by the term homogeneous-immersion, which, though honestly applied and correct as to the *idea*, is only approximately true at present.

In point of fact, no truly homogeneous-immersion fluid has as yet been discovered, so far as I can learn. That is, no fluid whose optical properties are *absolutely identical* with those of the front lens of any objective. The *refractive* power of crown glass has been closely approximated, but minute differences of *dispersive* power remain; and even if this difficulty could be overcome, the varying refractive and dispersive powers of various samples of crown glass must always remain an unknown quantity in our problem, to be provided for by some kind of adjustment.

This fact has been recognized by at least one maker, who advises to correct for extremely thick or thin covers, by means of the draw-tube of the microscope, and furnishes with some of his homogeneous-immersion lenses (so-called) *two* fluids, one for use with direct central light, and the other with very oblique light.

Of course it follows that for perfect accuracy of correction by means of the immersion fluid, a different fluid would be needed for each degree of obliquity of illumination. That this would involve serious inconvenience hardly needs demonstration; more especially when we consider that it is often desirable to examine an object under *gradually* varying obliquity of illumination, from direct central to the most oblique the lens can utilize.

Another item is that, when in use, the microscope has an additional optical combination not furnished by the maker, viz., the human eye; and that human eyes vary, and this variation must be compensated for in some way.

It appears, then, that the homogeneous-immersion system does not entirely obviate the necessity for adjustments of some kind, though it greatly lessens their *extent*. That these small, residual adjustments can be made with more ease, rapidity and accuracy by means of the screw-collar moving the back system of the objective, than by means of varying the distance between the objective and eye-piece by means of the draw-tube, or by varying the refractive and dispersive powers of the immersion medium by means of mixtures of various oils, etc., in varying proportions, will, I think, on consideration, be generally admitted.

But this greater ease, rapidity and accuracy of adjustment with homogeneous-immersion (so-called), is not the only argument in favor of the retention of the adjustable mounting for objectives. Most immersion fluids are apt to vary in their optical properties with their age or the state of the weather. One of the best of them, the solution of the sulpho-carbolate of zinc in glycerin, has its refractive power increased in very dry weather and decreased in very wet weather. In this case it is more convenient to turn the adjustment-collar slightly, than to make a new solution for immersion.

Again, it is often desirable to use an objective with a much longer or shorter tube than it was specially constructed for, or to use some other immersion medium than its own, water or glycerin for instance, for some special purpose. Here, again, the advantage, nay, the necessity, of the adjustable mounting, becomes evident. I believe then that I have shown:

First, that homogeneous-immersion has not been and is not likely to be more than approximately attained.

Second, that even if it should be fully attained, so far as the front lens of the objective is concerned, the varying refractive and dispersive powers of different eyes, and different samples of cover glass would always remain to be accounted for.

Third, hence adjustment of some kind will always be necessary.

Fourth, that a well made adjustable mounting for the objective is the most convenient, satisfactory and perfect arrangement for this purpose yet devised.

Fifth, that by means of such an adjustable mounting the range of usefulness of an objective, as well as the convenience of using it, are greatly increased, and therefore:

Sixth, homogeneous objectives (so-called or real), as well as all other objectives of wide angle, should be made adjustable.